International Journal of Research in Interdisciplinary Studies
Volume 1, Issue 2, October 2023
https://www.ijris.com

Comparative Study of Biogas Formation Using Different Locally Sourced Substrates

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Abstract— This research was done to ascertain the volume of biogas produced using different organic biomass. Co-digestion method of anaerobic digestion in biogas production was used and has proved to enhance the quantity of biogas produced. For containers 1, 2, 3 and 4; there are reasonable amount of gas production for container 4 which is for co-digested substrates. The ratio of the 4 containers at day 15 shows 0.10: 0.11: 0.12: 0.16: and 0.20. This shows that containers which represent cow dungs, poultry dungs and sewage for day 3, 6, 9, 12 and 15 are in the percentage of 14.49%, 15.94%, 17.39%, 23.19% and 28.99%. The 28.99% explains why co-digestion produces more biogas.

***Index Terms*— Substrate, Co-Digestion, Anaerobic, Biogas, Methanogen, Fermentation.**

1. Introduction

Biogas is produced during Anaerobic digestion. It can also be called anaerobic fermentation. It is anaerobic because oxygen is not needed for the bacteria to act on the substrates. It is a multistep chemical and biological process where organic matter (food waste, cow dung, human excreta etc, is broken down in the absence of oxygen and converted into biogas via complex interactions of microorganisms [1]. The process usually takes place in specifically designed plants known as bio-digesters under set conditions or occurring naturally in marshes and landfills. The production of biogas from biodegradable matter is not limited to using only one type of feedstock at a time. When more than one biomass is used for anaerobic digestion, this is referred to as co-digestion. Significance of co-digestion cannot be overemphasized. It stabilizes nutrients in the digester while also increasing the amount of feedstock available for digestion [2]. Many feedstocks in Botswana such as cow dung, food waste, agricultural biomass have been identified as feedstock for biogas generation. Biogas is a combustible mixture of gases produced through anaerobic digestion of organic matter. The main constituents of the gas are methane (CH_4) which makes about 55-70% and carbon dioxide (CO_2) making about 30-45% of biogas. Hydrogen sulphide makes less than 2% of the gas and with other gases in small traces. Biogas offers benefits such as; used as an energy source, environmental protection etc.

A. Aims and Objectives of the Research

To use different or combination of locally sourced waste in biogas production and compare the volume of gas produced so as to be able to suggest which substrate should be used.

2. Materials and Methods

A. Sample Collection

The samples used in this research/investigation include cow dungs, poultry dungs and sewage from underground household sewage tank. These three samples were taken to the research site immediately after collection from the sample site. Cow and poultry dung were collected using empty rice bag. For the sewage from underground tank, it was collected using a 25Lt capacity bucket because it is in semi-liquid form.

Fig. 1. Slurry preparation and co-digestion

B. Physical Analysis of the Three Samples

Temperature and pH of the samples were tested using thermometer and pH meter. The values were recorded and shown in table 1.

C. Slurry Preparation and Digester Fabrication

The digesters were fabricated using an empty paint bucket.

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They were made in such a way that they are water and air tight. These were shown in figure 1 below.

The slurry for anaerobic digestion were prepared as follows

- One kilogram of cow dungs was mixed with five liters of water and thoroughly mixed to ensure homogeneity.
- One kilogram of poultry dungs was mixed with five liters of water and thoroughly mixed to ensure homogeneity.
- Coming to the sewage from underground tank; because it is in semi-liquid form, a small calibrated plastic bucket was used to transfer three liters of it and mixed with two liters of water.
- Combing of the three samples (0.5kg each were mixed with two liters of water)

The materials used are follows,

Thermometer, pH meter by Hana, Electronic weighing balance by Hana and Locally purchased bucket.

D. Introduction of the Slurry into the Digester

At the end of slurry preparation, they were poured into the digester and labeled as follows.

- D1(Digester I) = For slurry made from cow dung
- D2 (Digester II) = For slurry made from poultry dung
- D3 (Digester III) = For slurry made from sewage
- D4 (Digester IV) = For slurry made from combination of the three.

The four digesters were kept in an open place where they will have contact with sunlight. But a shade was used over them. Plastic hoses were used to connect the digesters to the two-liter gas collection plastic with valve. This was done by connecting the hose to the gas outlet

E. Fermentation, Monitoring and Measurement

The digestion processes were monitored and the mass of the gas collection container determined at 3 days interval for 15 days. The mass of the empty containers was measured and taken at day zero and recorded as M0. Others were recorded as M3, M6, M9, M12 and M15. The gas collection containers were kept at about 2 feet below the digester. Mass of the gas was calculated by subtracting the mass of the container at day zero from the mass at other days like; mass of gas on day 3 is M3-M0.

3. Results and Interpretation

The results obtained were as follows using the electronic weighing balance and recording accordingly.

The tables above are for the raw data measured and calculated. Table 2 shows the measurement obtained from the gas collection container. The measurement was done on day 0-15. Table 3 shows the calculated volume of gas produced.

From the graphs in figures 2-5, they show significant increase in the biogas production. Container 3 and 4 show the highest biogas production for sewage and combination of the substrate also known as co-digestion as suggested in research done by [2]. Studies demonstrated that using co-substrates in anaerobic digestion system improves the biogas yields due to the positive synergisms established in the digestion medium and the supply of missing nutrients by the co-substrates [3]. In another report, co-digestion of cow dung with pig manure increased biogas yields as compared to pure samples of either pig or cow dung. According to the experimental results obtained, a mixing ratio of cow dung: food waste of 1:2 was found to be the optimum substrate mixture for biogas production. This mixing ratio yielded the highest biogas production [4].

It was also observed that the quantity of gas produced between day 6 and 9 was affected. This could be attributed to weather as there was not enough sunlight as It rained on those days. This supported that temperature is one of the factors for digester to function well as said by [5]. According to [2] single substrates probably lack buffering and desired nutrient content therefore resulting in an inadequate anaerobic digestion environment. Co-digestion offers several advantages when compared to digestion of single feedstock, such as better balance for nutrients (e.g., C/N ratio), good capacity for buffering [6].

Table 1
Physical analysis of the three samples

Sample	Nature of sample	pH of sample	Temperature of sample(^{0}C)
Cow dungs	Soft/solid	6.7	28
Poultry dungs	Soft/semi powdered	6.3	32
Sewage from	Watery	7.3	35

Table 2
Raw measurement of gas collection container from day 0 to day 15

Digester	Mass in kg. Day 0	Mass in kg. Day 3	Mass in kg. Day 6	Mass in kg. Day 9	Mass in kg. Day 12	Mass in kg. Day 15
CONTAINER 1	0.0983	0.1122	0.1200	0.1370	0.2000	0.2308
CONTAINER 2	0.0956	0.1201	0.1603	0.1750	0.2150	0.2355
CONTAINER 3	0.0980	0.1823	0.1995	0.2000	0.2200	0.2410
CONTAINER 4	0.0977	0.2000	0.2153	0.2200	0.2608	0.3000

Table 3
Calculated measurement of gas in gas collection container from day 0 to 15

Digester	Mass in kg. Day 0	Mass in kg. Day 3	Mass in kg. Day 6	Mass in kg. Day 9	Mass in kg. Day 12	Mass in kg. Day 15
CONTAINER 1	0.0000	0.0139	0.0221	0.0324	0.1018	0.1325
CONTAINER 2	0.0000	0.0245	0.0645	0.0794	0.1199	0.1399
CONTAINER 3	0.0000	0.0843	0.1015	0.1020	0.1220	0.1430
CONTAINER 4	0.0000	0.1020	0.1175	0.1223	0.1630	0.2027

4. Conclusion

Biogas formation can be achieved using locally sourced substrate or biomass [5]. In this research, comparison of the individual substrate and the mixture of the three showed that poultry dung produced higher than cow dung. But it was observed that for a maximum production, co-digestion technique should be used. This complied with what was suggested by [4].

Fig. 2. Biogas production in container 1 for day 0-15

Fig. 3. Biogas production in container 2 for day 0-15

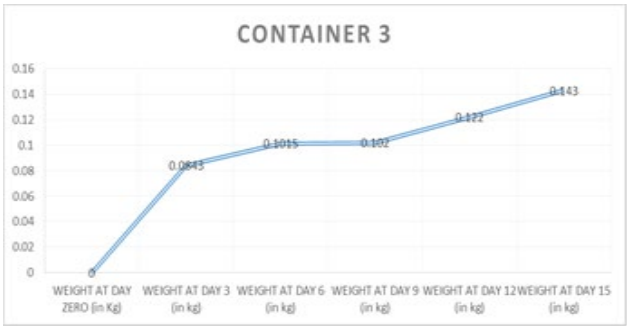

Fig. 4. Biogas production in container 3 for day 0-15

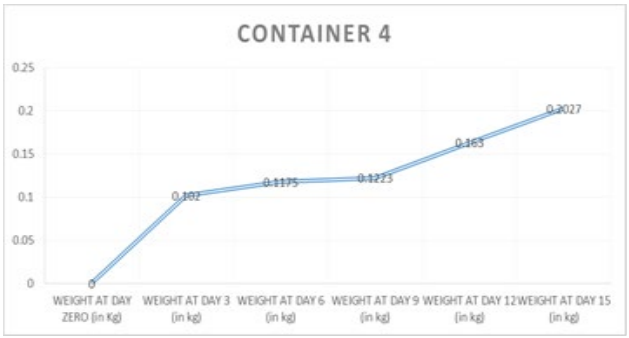

Fig. 5. Biogas production in container 4 for day 0-15

References

[1] B. Salam, S. Biswas, and S. Rabbi, "Biogas from Mesophilic Anaerobic Digestion of Cow Dung Using Silica Gel as Catalyst," in *Procedia Eng*., vol. 105, pp. 652–657, 2015.

[2] S. Kumar, R. Joshi, H. Dhar, S. Verma, and M. Kumar, "Improving methane yield and quality via co-digestion of cow dung mixed with food waste," in *Bioresour. Technol*., vol. 251, pp. 259–263, November 2017.

[3] E. P. Makhura, E. Muzenda, and T. Lekgoba, "Effect of Substrate to Inoculum Ratio on Biogas Yield," in *J. Clean Ener. Tech*., vol. 8, no. 2, pp. 16–19, 2020.

[4] Emmanuel P M, Edison M, and Tumeletso L., "Effect of co-digestion of food waste and cow dung on biogas yield," in *E3S Web of Conferences*, 181, 01005, 2020.

[5] Osuji MI., Ogbulie JN., Nweke CO & Nwanyanwu CE., "Acid-base pretreatment of lignocellulosic biomass to facilitate recovery of fermentable sugar for anaerobic fermentation," in *Int. J. of Frontline Re*., 2022.

[6] A. K. Jha, J. Li, L. Zhang, Q. Ban, and Y. Jin, "Comparison between Wet and Dry Anaerobic Digestions of Cow Dung under Mesophilic and Thermophilic Conditions," in *Advances in Water Resource and Protection*, vol. 1, no. 2, 2013.